Contract Prolongation in Scientific Institutions: The Principal's Optimum under Moral Harzard

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Zusammenfassung

Wir betrachten das Problem zwischen einem Arbeitgeber und einem Arbeitnehmer, der ein Forschungsprojekt mangels einer innovativen Idee nicht termingerecht abgeschlossen hat. Die Fertigstellung des Projektes würde einen bestimmten Geldbetrag einbringen. Die zentrale Frage ist, ob der Forscher eine Vertragsverlängerung für dieses Projekt bekommt. Dies würde mit einer gewissen Wahrscheinlichkeit den Geldbetrag einbringen, aber auch Kosten verursachen. Ein Prinzipal-Agent Modell wird formuliert, indem die Anstrengung des Agenten und die zur Verfügung gestellte Zeit über die Erfolgswahrscheinlichkeit entscheiden. Der Agent entscheidet über die Anstrengung gegeben die Forschungszeit, das Gehalt und die Verlängerung der Vertragsdauer. Diese werden vom Arbeitgeber mit Kenntnis der Bedingung erster Ordnung des Agenten festgelegt. Für die Entscheidung über die Dauer der Vertragsverlängerung ist entscheidend, wie stark die Anstrengung und die Forschungszeit die Chance auf einen erfolgreichen Abschluss beeinflussen und wie der Agent mit der Anstrengung auf eine längere Forschungszeit reagiert. Alle theoretisch möglichen Ergebnisse des Modells werden besprochen. Insbesondere die Entscheidung der wirtschaftswissenschaftlichen Fakultät der Universität Maastricht, Verträge nicht zu verlängern wird auf dem Hintergrund des Modells betrachtet.

Abstract

We consider the problem between an employer and a research employee who has not finished a research project in time because of a lack of an innovative idea. The research project yields money in case of finishing it. The decision to be made is whether or not the researcher gets a contract prolongation. Giving him or her a prolongation is associated with a positive expected return for the employer, which may or may not exceed the expected costs of the prolongation. A principal-agent problem is formulated, in which the probability of success is determined by the research time allotted and the effort of the agent. The agent decides upon his effort given the salary (reduction), the share of research time, and the length of the prolongation. The employer takes a decision on these variables knowing the agent's first-order condition with respect to effort. For the decision on the length of the

* I am grateful to Rohini Acharya and Theon van Dijk for comments on an earlier version. Responsibility is entirely mine.

contract prolongation it is of crucial importance what impact the research-time share (or the teaching load) has on the probability density of success and on the effort chosen by the agent. All theoretically possible outcomes are discussed. In particular the decision of the faculty of economics at Maastricht University, not to give any prolongation, is discussed in terms of the model.

1. Introduction

In a world with heterogeneous individuals with ordinal utility functions of some individuals, constitutions of all institutions are political compromises. The constitution of a nation state can allocate rights to the central or the individual level or to some other level in between. The political compromises may change over time such that rights are allocated to different institutions than before the change. As a consequence those getting the rights for some decisions will have to find their own way how to make there decisions. In short, after a change in the allocation of rights new problems may rise. In this paper we consider an example of such a case because the consequences of constitutional change should be taken into account when deciding upon it.

Recent constitutional change in the Netherlands has shifted rights from the level of the central state to that of the provinces and municipalities, from the level of ministries to the level of universities, faculties or even departments and from rigid laws to the discretion of commissions. One such example is the right to decide on the prolongation of contracts concerning doctoral dissertations. In earlier times this decision problem was not left to faculties but rather decided upon by law. Recently it has been shifted to the discretion of the faculties. This means that constitutional change has transformed a central government decision into a principal-agent problem, where the faculty is the principal and PHD students are the agents. In this paper we will consider this problem in detail.

It is a feature of research contracts that a fixed payment per project has to be paid if the project is finished in time. One example from the Netherlands is doctoral dissertation premiums paid by the government as support of basic scientific research. The uncertain outcome with respect to the success of the doctoral dissertation as well as other projects poses an interesting problem for the contract length of the PHD student who normally gets a contract for four years. If the student does not finish his dissertation within the time allotted, the faculty will loose the prize paid by the government unless the student can organize some other source of financing, which will not be possible in general. If the faculty offers the student a contract prolongation, there will probably be a dissertation after some time and therefore the government prize can be gained with some likelihood. The problem for the faculty will then be to decide how long to extend the contract, at what salary reduction and which labour time. An essential point in the problem is that the researcher has an impact on the probability of success through his effort and the faculty has an impact on it through the labour time requested for teaching, the salary and the length of the prolongation.

As a faculty will not like to make a new decision in each individual case it will form an idea of an average student having this problem and set up rules that can credibly be announced beforehand. The student knowing the rules for a potential prolongation of his contract can take this into account during his behaviour in the first part of the game before the prolongation gets relevant. We consider here only the making of the rules for the second part of the game.[1] More specifically, we consider the behaviour of the researcher and the derivation of administrative rules by the faculty as a principal-agent problem. The scope of the problem, however, may be much broader than just the university research. The essence is that the principal receives a prize for successfully finishing a project in time, and the agent has an impact on the probability through his effort. Obviously, the Dutch situation with faculties having the right to choose these rules and having an incentive to do so is different from the German situation where the rules are determined by law. In particular there is no reason to worry about a potential inflation of dissertations because of the payment of a prize by the government. Dutch institutions are set up in a way that this is avoided, because the prize does not go to the supervisors or (Co-) promoters of a dissertation and they cannot be members of the commission, which judges about the dissertation and is installed by the dean.

In the model presented in section 2, the representative researcher maximizes (in section 3) his expected utility for the duration of the contract. He can increase the probability of successfully finishing his project by choosing a higher level of effort, which produces some disutility. The impact of the employers' choice variables on the effort of the researcher is analyzed in section 4. The employer is assumed to know this behaviour and determines (in section 5) the salary, the working hours for research and the length of time for which the contract is prolonged. His objective is to maximize the expected return minus that part of the prize that is used for research. Section 6 sums up and concludes. A list of abbreviations can be found at the end of the paper. We discuss related literature during the presentation of the model.

2. The model

In a more formal way the problem described above can be presented as follows. At time zero the regular contract of the researcher expires and prolongation may begin. At time T researcher's contract *prolongation* expires. T has to be decided upon by the principal (employer, research institute). The agent determines the effort, e, in periods $0 < t < T$ through maximization of utility U derived from the salary $(1-s)\,S$ and from the effort. S is the last full salary of the researcher during regular contract length fixed by the government (thus, till zero). This can be set equal to one in the following when helpful. $1 - s$ is the percentage of the full salary paid after 0 till T or the point in time of success if reached earlier. For the mere sake of simplicity it is assumed that the income is completely used for consumption. Utility has to be weighed by the likelihood that research will be finished successfully. This probability depends on the labour time of the researcher, x, and on the effort e. Dependence on e implies moral hazard if the effort is not observable for the employer or third parties. As a consequence the researcher cannot insure against failure because he has a non-verifiable influence on the likelihood of success. We specify

$$P = 1 - e^{-h(x,e)v(t)}$$

[1] An interesting paper on the determination of fixed expiration dates for the *first* period in cases of *individual* contracts rather then writing rules for representatives agents as considered here is Cantor (1988).

P is the probability function for research success (and e^{-hv} for failure) with random time variable t (and ⊗ its realization), and a concave function h, with properties $h_1, h_2 > 0$, $h_{11}, h_{22} < 0$, $h_{21} >=< 0$, $h(0,0) = 0$. The derivative of the probability function with respect to time t is

$$p = h(x,e)v'(t)e^{-h(x,e)v(t)}$$

p is the density function of t for success and $p/(1-P) = hv'$ is the generalized hazard rate (see Kamien/Schwarz, 1980): the probability of research success in t conditional on no research success until t. When the researcher succeeds at some point in time ⊗ < T, that is before the prolonged contract expires, he receives his full salary again and returns to some standard effort $\bar{e}$. This provides him with utility U^2, where the upper index indicates just another phase of life. It is attractive to strive for success at ⊗ < T if $U^2 \geq E(U)$.[2] With utility function $U[(1-s)S, -e]$ of the employee with properties $U_1, U_2 > 0$, $U_{22} < 0$ and the discount rate ρ, the objective function for the household is

$$\int_0^{\otimes} e^{-\rho t} U(1-s,-e)h(x,e)v'(t)e^{-h(x,e)v(t)}dt + \int_{\otimes}^{T} U^2 e^{-\rho t} dt$$

Henceforth it is taken for granted that the constraint $U^2 \geq E(U)$ is fulfilled and not binding. Moreover, there is the outside option of giving up the effort to write a doctoral dissertation or finishing some other project, which is assumed to yield utility U^0. With $S(1-s)$ as salary costs and $q(1-x)$ as return from education, the employer hopes to get F, the prize for research success, which he gets if the researcher succeeds. The employers expected net return is expressed as follows

$$\int_0^{T} Fh(x,e)v'(t)e^{-h(x,e)v(t)}dt + q(1-x) - (1-s)S$$

Labour time x is assumed to have an impact on the probability of success of the research and on revenues from teaching. Neither leisure nor an impact of x on the prize F is assumed to exist. More research time decreases the time a researcher is available for teaching or administration, which yields q per unit of time. On the side of the researcher it is assumed that he can react with his effort on changes in the labour time imposed by the principal.

The following cases for the part $v(t)$ of the probability function can be distinguished (see Kamien and Schwarz, 1980): $v(t) = t$ and $v' = 1$ for the exponential distribution, $v(t) = t^w$ and $v' = wt^{w-1}$ for the Weibull distribution and $v(t) = e^{wt} - 1$ and $v' = we^{wt}$ for the extreme value distribution, where the e is Euler's e, not the effort used before and later.

[2] In terms of signaling language this means that there are only two possible signals that can appear at each period t: 'Success' or 'no success'. Once the signal 'success' appears the game is essentially over and the researcher gets his reward U^2 for the rest of the time until T.

3. The problem of the representative researcher household

The representative researcher household is assumed to

$$Max_e L = \int_0^{\otimes} e^{-\rho t} U(1-s,-e) h(x,e) v'(t) e^{-h(x,e)v(t)} dt + \int_{\otimes}^{T} U^2 e^{-\rho t} dt$$

The first-order conditions for this problem, $\partial L/\partial e = 0$, *for* $0 \leq t \leq T$ requires:

$$-U_2(1-s,-e)v' h e^{-hv} + Uv'\left[h_2 e^{-hv} + h(-h_2)ve^{-hv}\right] = 0$$

Dividing by $v'e^{-hv}$ and rewriting h_2 outside the brackets yields (for $0 \leq t \leq T$)

$$-U_2 h + Uh_2\left[1 - hv\right] = 0 \qquad (1)$$

Expected marginal disutility from effort must be outweighed by the marginal increase in the density of the success probability, where the conditional success probability h is increased and the probability of failure e^{-hv} is decreased and the former must outweigh the latter, such that an interior solution requires $1 - hv > 0$. Growth of v over time, which follows from the assumptions on v, will drive h down as hv approaches 1 (or earlier) and thus either x or e or both – the arguments in h - will decrease from some time onwards. For constant or growing given x, e would decrease. However, x will be determined by the principal and may go down as well.

The second-order condition requires

$$A \equiv -U_{22}h - U_2 h_2 - U_2 h_2(1-hv) + U\left[h_{22}(1-hv) + h_2(-h_2 v)\right] < 0$$

As all terms are negative according to the concavity assumptions on U and h this condition is fulfilled and (1) has a unique solution.[3]

4. The principal's comparative static impact on the representative agent's effort

The contract prolongation being made to make an uncertain outcome successful, the researcher household has an impact on the probability of success through his choice of e. This is the moral hazard problem, which excludes the possibility that there will be an insurance against the failure in research unless the effort of each researcher is observable by the insurer and verifiable for third parties. In the next step it is investigated which values in (1), given from the employer, influence e positively or negatively.

$$\partial e/\partial x = -A^{-1} \cdot \{\underbrace{-U_2 h_1}_{+} + \underbrace{U}_{-}[\underbrace{h_{21}}_{\text{sign } h_{21}}(1-hv) + \underbrace{h_2(-h_1 v)}_{-}]\} < (>) 0 \qquad (2)$$

[3] By implication we do not have to bother separately about convex distribution function conditions and the monotone likelihood ratio condition (see Gravelle and Rees chap.22.E).

All impacts of x run via h or h_2. The first term in brackets says that higher research time x increases the expected disutility from effort because the conditional success probability is increased, thus providing a disincentive for effort. The second term says that higher research time x increases (decreases) the influence of higher effort on the probability density of success if h_{21} >(<) 0, providing an incentive for higher (lower) effort. The third term says that higher x increases the speed with which hv is running against 1 and increases the speed with which the probability density of success declines, thus providing a disincentive for effort. If $h_{21} < 0$ all terms are negative and effort decreases as a reaction on more research time.

For the impact of the salary on effort we receive

$$\partial e / \partial (1-s) = -A^{-1}\{\underbrace{-U_{21}h}_{+}+\underbrace{U_1 h_2}_{+(-)}\underbrace{(1-hv)}_{+}\} > (<) 0 \tag{3}$$

The impact of a higher salary on effort is positive if $U_{21} \leq 0$.[4] Thus, there is no positive impact of salary reduction on effort, but a negative one on utility. For $U_{21} > 0$ the effect is ambiguous.

As time goes by, the cumulative probability of failure decreases because of the time impact in v. The ceteris paribus effect (i.e. at constant salary and research time) of t on e is

$$\partial e / \partial t = -A^{-1}\{Uh_2(-hv')\} < 0 \tag{4}$$

The interpretation of (4) is that you distribute effort parallel to the difficulty (low cumulated probability) of success: the higher the probability of success, the lower the effort, or, in other words, people get lazy because time works for them. Because the partial effect of x on e was also ambiguous it is not certain that choice of x can help the employer-principal to counteract this effect of time. If $h_{21} < 0$, *reduction of the research* time increases the effort. Falling effort can also be counteracted by an *increasing salary* (lower s) if $U_{21} < 0$ (sufficient). Terminating the contract at time T limits the possible fall in effort.[5]

5. The employer's problem

The employer takes (1) into account when maximizing the expected return from the research. It should be reemphasized that the employer has an image of a representative agent expressed through (1) and too little information or too high information costs to base contracts with individual researchers on. The essence of the problem is not one of revealing private information on hidden action or

[4] Stiglitz and Weiss (1983) mention this effect as one of the reasons why termination of contracts may be preferable to other reactions on weak performance.

[5] Termination is not imposed to reveal hidden information as in Sen (1996). Incentive effects of termination are also absent – except in regard to timing of course - because PHD contracts end anyway - with and without success.

information of the agent through monitoring[6] or other mechanisms, but rather one of writing rules to be announced to and designed for an image of a representative agent.[7] His problem[8] is to

$$Max_{T,s,x,\lambda} I = \int_0^T \{Fh(x,e)v'(t)e^{-h(x,e)v(t)} + q(1-x) - (1-s)S + \lambda[Uh_2(1-hv) - U_2h]\}dt +$$

$$+ \mu[\int_0^\theta U(1-s,-e)h(x,e)v'(t)e^{-h(x,e)v(t)} - U^0 dt]$$

The optimal termination for the principal requires for $t = T$

$$\partial I / \partial T = Fhv' e^{-hv(T)} + q(1-x) - (1-s)S >=< 0 \tag{5}$$

The optimal contract termination from the point of view of the risk-neutral employer is reached when expected returns of the period equal costs.[9] As h approaches $1/v$, e^{-hv} approaches e^{-1} and hv' approaches v'/v which approaches zero as t goes to infinity for the exponential distribution and the Weibull distribution and w for the extreme value distribution. Thus for the first two special cases of the distribution we can be sure that such optimal termination point in time exists because revenue falls below costs for positive $1\text{-}s$ unless revenues from teaching are covering the salaries completely. Permanent contracts for one project are unlikely outcomes here. s would have to go to unity (no salary). In case of an extreme value function we get $Fwe^{-1} - (1\text{-}s)\ S >=< 0$ if there are no revenues from teaching. This provides a unique solution for s if there is an interior solution for a termination of the contract. However, corner solutions cannot be excluded.

Maximization with respect to the salary reduction yields

$$\partial I / \partial s = S + \lambda[\underbrace{-U_1Sh_2(1-hv)}_{-} + \underbrace{U_{21}Sh}_{-\,(+)}] + \mu[U_1(-1)h(x,e)v' e^{-h(x,e)v(t)}] >=< 0, 0 \le t \le T, \tag{6}$$

The term in the first pair of square brackets equals $\partial e/\partial s >=< 0$, which has the opposite sign of (3). In case of an interior solution with $\partial e/\partial s < 0$, the employer will reduce the full salary by a percentage that equalizes his cost reduction and the marginal impact of the agent's effort reduction on the principal's income as derived in

[6] See Flinn (1997) for an interesting example. Nevertheless we speak of moral hazard here because both the agent and the principal have an impact on the probability via h(e,x) and failure cannot be insured against unless third parties could observe and verify the effort.

[7] It is a standard assumption in the principal-agents models that effort cannot be *observed* but the principal knows all *functions and therefore has perfect information except for the effort.* He therefore can *calculate* the agent's effort ex-ante, but not *observe* it and prove it to third parties because the ex-post outcome is determined not only by the effort but also by the random process. There, both parties have an impact on the probability. If the problem is considered with the purpose of writing rules, the principal does not need to know the exact utility function of an agent but just needs a subjective idea of these preferences.

[8] In general the principal's problem is a classical calculus of variation problem (see Ross 1973). However, in the problem considered here the random variable appears only at the upper bound of the integral of the agent's objective function. Therefore the hazard rate models have the special form of equation (12) in Ross (1973) where the dynamic optimization part drops out.

[9] The termination does not occur without reason as it may in recent government contracts [see Robinson (1996)].

(3) plus the expected marginal reduction of utility of the agent. This latter term requires a lower reduction of effort compared to the case $\mu=0$, and therefore a lower salary reduction to assume participation of the agent. λ must be positive if the incentive-compatibility constraint is binding. Thus, the assumption of maximization of expected returns leads to a reduction of researchers' effort in response to a salary reduction in case of a non-binding participation constraint. This possibility should be kept in mind in the transition from a governmental to an "entrepreneurial university" as it is modeled here. The effort reduction is a cost for the agent, which is caused by the reduction of the salary. If $\partial e/\partial s < 0$ leads even to a negative sign of (6) this means that a salary reduction provokes an effort reduction that makes it unprofitable to reduce the salary which therefore it set equal to S, i.e. $s=0$. If $\partial e/\partial s > 0$, the additional effort is a return to the principal from the salary reduction. In this case (s)he can set a higher salary reduction s (in comparison to the case of a decreased effort). If the 'larger' sign of (6) holds and s will equal unity, which will imply that the salary becomes zero. This can only be the case if $U_1(0,-e) < \infty$ (necessary).

Optimal research time provision requires

$$\partial I/\partial x = v' e^{-hv} F h_1 (1-hv) - q + \lambda \left[U h_{21} (1-hv) + U h_2 (-h_1 v) - U_2 h_1 \right] + \mu U h_1 v' e^{-hv} (1-hv) >=< 0 \quad (7)$$

The first term says that increasing the research time increases the probability of success and thus the expected return of the employer-principal. The term in square brackets measures the effect of x on e, which was shown to be of unclear sign in (2), the comparative static effects on the researchers (agents) optimum, as long as $h_{21} > 0$, but of negative sign if $h_{21} < 0$ (sufficient). In this latter case effort reduction is a cost of increasing the research time. The final term indicates an increase in the agents utility, which allows for a lower increase in research time x, which in turn softens the decrease of effort if $h_{21} < 0$. Using (2) for the last expression in (7), this becomes:

$$v' e^{-hv} F h_1 [1-hv] + \lambda \left[-A \cdot \partial e/\partial x \right] + \mu U h_1 v' e^{-hv} (1-hv) >=< 0 \quad (8)$$

As $1 - hv$ was shown to be positive in the first-order condition of the household, λ is positive and A is negative because of the household's second-order condition, the existence of an interior solution for an optimal share of research time requires $\partial e/\partial x < 0$. This was shown to be the case for $h_{21} < 0$ (sufficient) and for $h_{21} > 0$ if the corresponding term is not too large. However, for $\partial e/\partial x < 0$ the 'smaller' sign of (7) and (8) may hold. In this case a research time $x=0$ is chosen, because more research time leads to a very strong reduction of effort. Of course, in this case a research contract prolongation will not be signed.[10] If $\partial e/\partial x > 0$, however, the 'larger' sign in (7) and (8) must hold and the research time will be $x=1$, which means that the researcher has a zero teaching load, because all terms are positive. In this case of higher effort through a higher share of research time full support is given to research.

For e we find that

$$\partial I/\partial e = v' F h_2 [1-hv] + \lambda A = 0$$

[10] The results of termination of the contract or prolongation with salary reduction are also possible outcomes in Stiglitz and Weiss (1983). Their model is different in that wages are only paid in case of successfully finished projects.

The derivation of the participation constraint with respect to e is zero according to (1) and drops out. This condition confirms $1 - hv > 0$ because $A < 0$ is the second-order condition from the researcher household. Finally, the derivations with respect to the Lagrange multipliers equal zero, which ensures that the agent's first-order condition and the participation constraint are taken into account.

At the economics faculty of Maastricht University the commission in charge has decided not to allow for prolongations. What may be behind this decision from the perspective of the present model? This implies from (5) that $T = 0$. In all three cases of the function we get $v = 0$ and the exponential term in (5) becomes unity. v' becomes 1 for the exponential distribution, 0 or infinity for the Weibull distribution depending on whether w is larger or smaller than unity and w for the extreme value function. A low value of T is attractive if v' is low (the Weibull case with w larger than unity and the extreme value function case with small w). Otherwise, for large v', it is attractive to set the time variable very high (the case of a Weibull function with w > 1 and an extreme value function with high w). For all values of effort e, $0 \leq s < 1$ and $0 \leq x \leq 1$ a prolongation is expected to yield marginal losses, i.e. the 'smaller' sign of (5) holds, if $T=0$. This means that salary costs exceed the expected returns, unless $s = 1$.

Alternatively, $T = 0$ may be an interior solution that holds if $x = 0$ if $\partial l/\partial x < 0$ in (7). In this case we get $Fhv' + q - (1 -s) S = 0$ from (5) for *all* $T = t$. Because $h(o, e) = 0$, which yields $q - (1-s) S = 0$. The returns from the 100% teaching load are needed to cover a reduced salary and the reduction factor can be computed as $s = 1 - q/S$. Although there is perhaps a contract, it is a teaching contract and actually no research contract as $x = 0$. To get a negative value of (7) we must have $\partial l/\partial x < 0$. A look at (7) tells us that this requires a small value of F and U multiplied by $v'h_1e^{-hv}(1-hv)$, the impact of research time on the probability density of success, and a strong negative impact of research time x on effort e. Seemingly, these are the expectations that the faculty has in regards to researchers not finishing in time. Before the constitutional change in the Netherlands, researchers had permanent contracts in spite of this possibility.

6. Conclusion

In this paper we have captured the internal organization problem between a researcher and his employer that happens to occur when deadlines are not met. The problem is raised because of the Dutch governments' willingness to pay for contributions to basic scientific research only in case of success.

The main results of the model of this paper are the following:

i. A higher labour time for research will decrease the researcher's effort if a higher share of research time decreases the influence of higher effort levels on the probability density of success (hazard rate) [$\partial e/\partial x < 0$ if $h_{21} < 0$ (sufficient)];

ii. There is a negative impact of salary reduction on effort in the prolongation period if marginal disutility from effort is weakened by a higher salary [$\partial e/\partial s < 0$, if $U_{21} < 0$ (sufficient)];

iii. Researchers' effort is, ceteris paribus, decreasing over time because researchers optimally distribute effort inversely to the increasing cumulated probability of success ($\partial e/\partial t < 0$);

iv. An optimal, finite contract prolongation length, a salary reduction and research time share may exist, which provide some rules of thumb for the administration of the institution. If a higher share of research time, x, increases the influence of higher effort on the probability density of success (hazard rate) ($\partial e/\partial x > 0$ by a positive and sufficiently strong value of h_{21}) research time will be 100% ($\partial l/\partial x > 0$) and the teaching load will be zero. If, however, $\partial l/\partial x < 0$ the research time will be zero and no contract prolongation for research will be signed;

v. If the salary reduction has higher benefits than cost to the employer ($\partial l/\partial s > 0$ for which a positive and sufficiently large U_{21} is sufficient) the salary will be set to zero; this can only be the case if the marginal utility of the researcher from his salary is very low.

vi. Some of the implications of the decision of the economics faculty of Maastricht University to set the prolongation time equal to zero have been derived: i) Expected returns cannot cover a positive salary. ii) A positive salary can only be justified if they are fully covered by a 100% teaching load. The necessary assumptions behind this decision and revealed by our analysis are i) that effort is reduced with higher research time and ii) that the impact of higher research time on the probability of success is low.

Given the general and qualitative character of the results, it may be desirable to choose more specific functions for the utility function and the hazard rate. This would allow making scenarios for the numerical outcomes of the time horizon, the teaching load, and the salary reduction, which would have to be specified in a contract.

However, there may be possible extensions. One of them may be that the prize the employer gets can be thought of as not only consisting of money but also the value of a reputation for delivering in time, which might be a continuous function of the realized prolongation time, ⊗. The employer than has stronger incentives to provide more research time. However, this may be the case with projects paid by political institutions but will hardly be the case in basic scientific research where the cost of violating deadlines is not perceived to be so obvious or serious, because it is a public good.

The monopolistic character of a principal-agent relationship, which in this model allows the principal to increase the effort of the agent by choosing a salary reduction and the research time, is a market imperfection. The constitutional change that has shifted the rights for these choices to the employer thus has replaced a potential government imperfection into a monopolistic one. Regulators seem to believe that the former imperfection was larger than the latter one or, alternatively, the shift in the rights considered is just a by-product of other changes, which are held to be more important than the one considered.

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List of abbreviations

Zero	the period, at which researcher's regular contract expires and prolongation begins
T	period as contract prolongation expires
e	effort of researcher in period t
x	labour time of researcher
F	the prize for research success received by the employer (principal) if the researcher succeeds.
$P = 1 - e^{-h(x,e)v(t)}$	probability function for research success (and e^{-hv} for failure) with random time variable t, a concave function h, h_1, $h_2 > 0$, h_{11}, $h_{22} < 0$, $h_{21} >=< 0$ and the following cases for $v(t)$ (see Kamien/Schwarz, 1980): $v(t) = t$ and $v' = 1$ for the exponential distribution, $v(t) = (t)^w$ and $v' = w(t)^{w-1}$ for the Weibull distribution and $v(t) = e^{wt} - 1$ and $v' = we^{wt}$
$p = h(x,e)v'(t)e^{-h(x,e)v(t)}$	density function of τ for success
$p/(1-P) = hv'$	generalized hazard rate (see Kamien/Schwarz,1980): probability of successful research in t conditional on no research success until t.
q	the return of teaching activity.
S	last full salary of the researcher during regular contract length (fixed by the government); thus, till zero.
$1 - s$	percentage of full salary paid after t, completely used for consumption.
$S\,(1-s)$	salary costs to be attributed to research
$\int_0^T Fh(x,e)v'(t)e^{-h(x,e)v(t)}dt$	employer's expected return of F in t.
$U\,[(1-s)\,S, -e]$	employee's utility function with U_1, $U_2 > 0$, $U_{22} < 0$
ρ	discount rate